Pavement profiles : Effect of seasonal frost and permafrost degradation

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Context

Roads
on thaw-sensitive permafrost

Samson 2015

Roads
in seasonal frost context

Englobe 2015

Objectives

Develop an analysis tool for longitudinal surface profiles

Seasonal frost

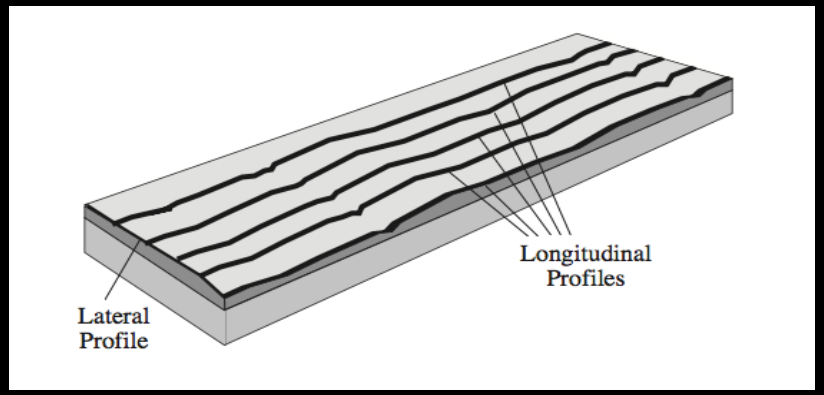
- Identify pavement degradation processes related to seasonal frost
- Develop guidelines for the selection of appropriate rehabilitation methods

Permafrost

- Identify profile characteristics related to permafrost degradation
- Allow for early identification of zones affected by permafrost degradation ⇒ thermal stabilization

Important notions

Pavement profile



Sayers & Karamihas 1998

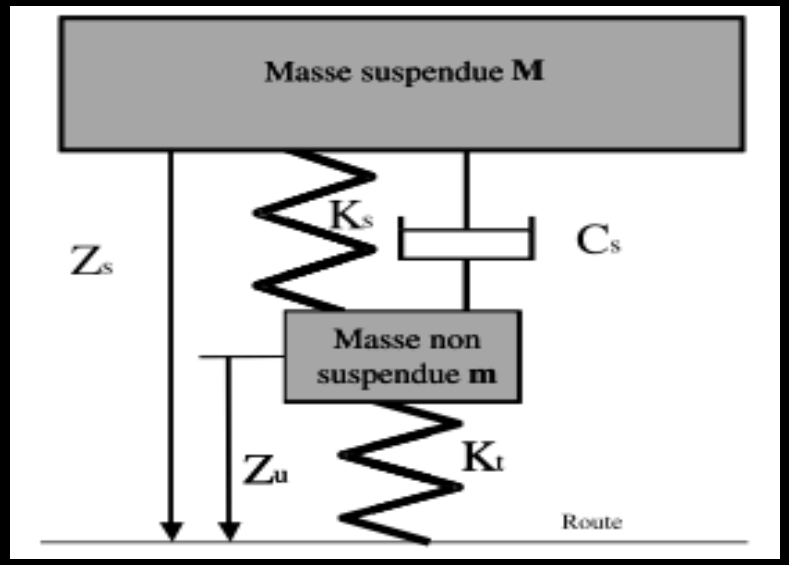
Roughness (smoothness)

Principal indicator of the ride quality and the overall condition of the pavement

Quantified with IRI

Quarter-car mechanical model

Vehicle response to differential elevations along pavement surface profile



Important notions

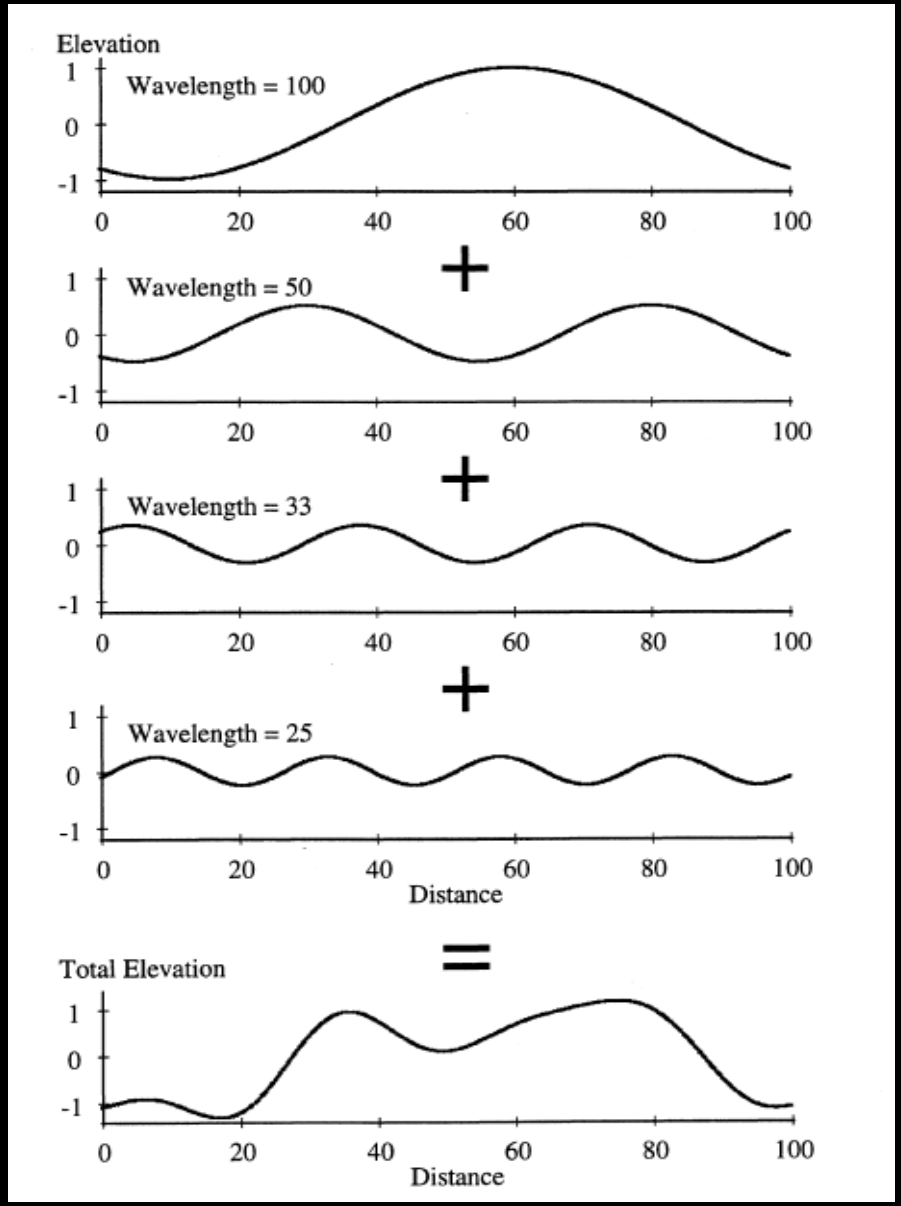
Profile wavelengths

Long wavelengths :

- Affect ride quality
- Associated with deep degradation processes

Short wavelengths :

- Affect mainly user safety
- Associated with near-surface deterioration processes



Sayers & Karamihas 1998

Methodology

Filtering profiles and calculating IRI

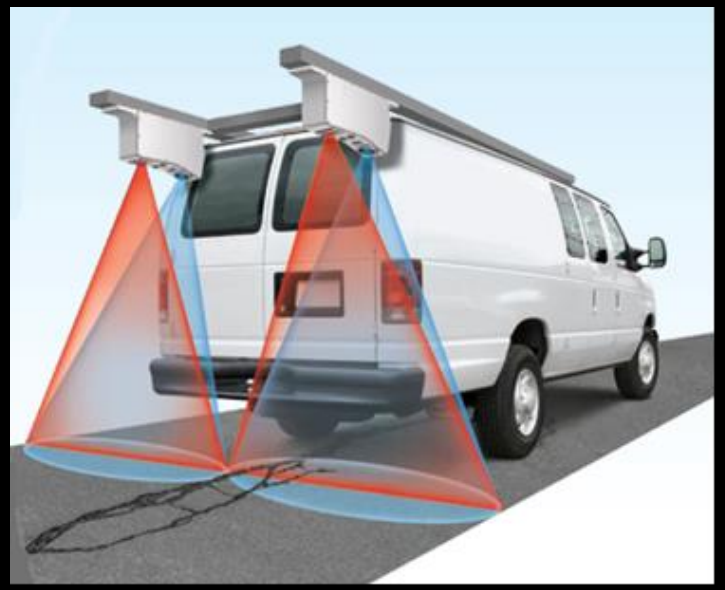
	Wavelength (m)	
	Seasonal frost	Permafrost
Short wavelengths	0.7 to 3	0,7 to 3
Long wavelengths	8 to 12	11 to 45

SEASONAL FROST

Methodology

Data acquisition

- Inertial profiler
- Laser Crack Measurement System (LCMS)



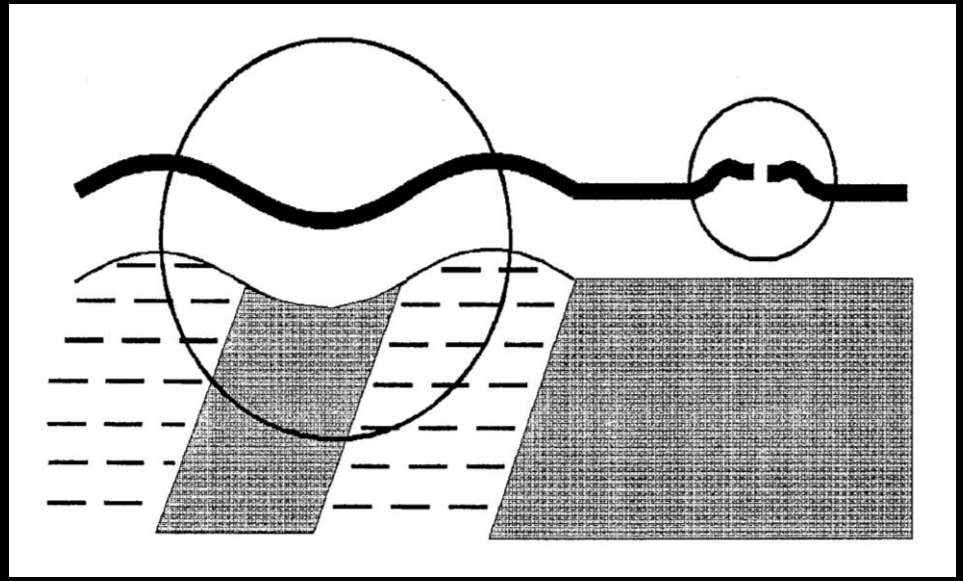
Englobe 2015 et Pavemetrics 2015

Longitudinal profiles

Filtering profiles and calculating IRI

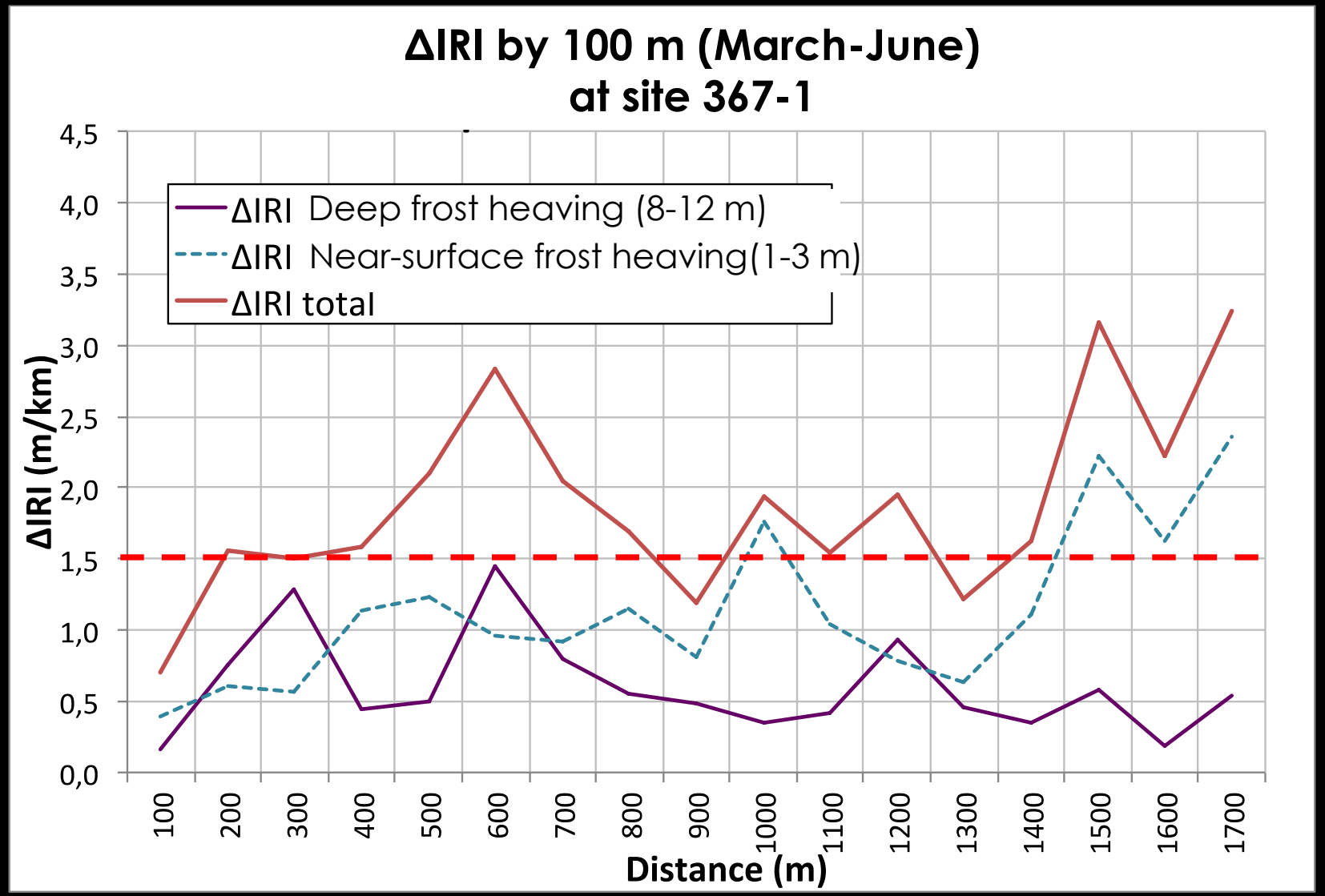
Wavelengths (8-12 m) → Differential frost heave of the subgrade soil

Wavelengths (1-3 m) → Frost heaving of cracks



Doré, 1997

Longitudinal profiles

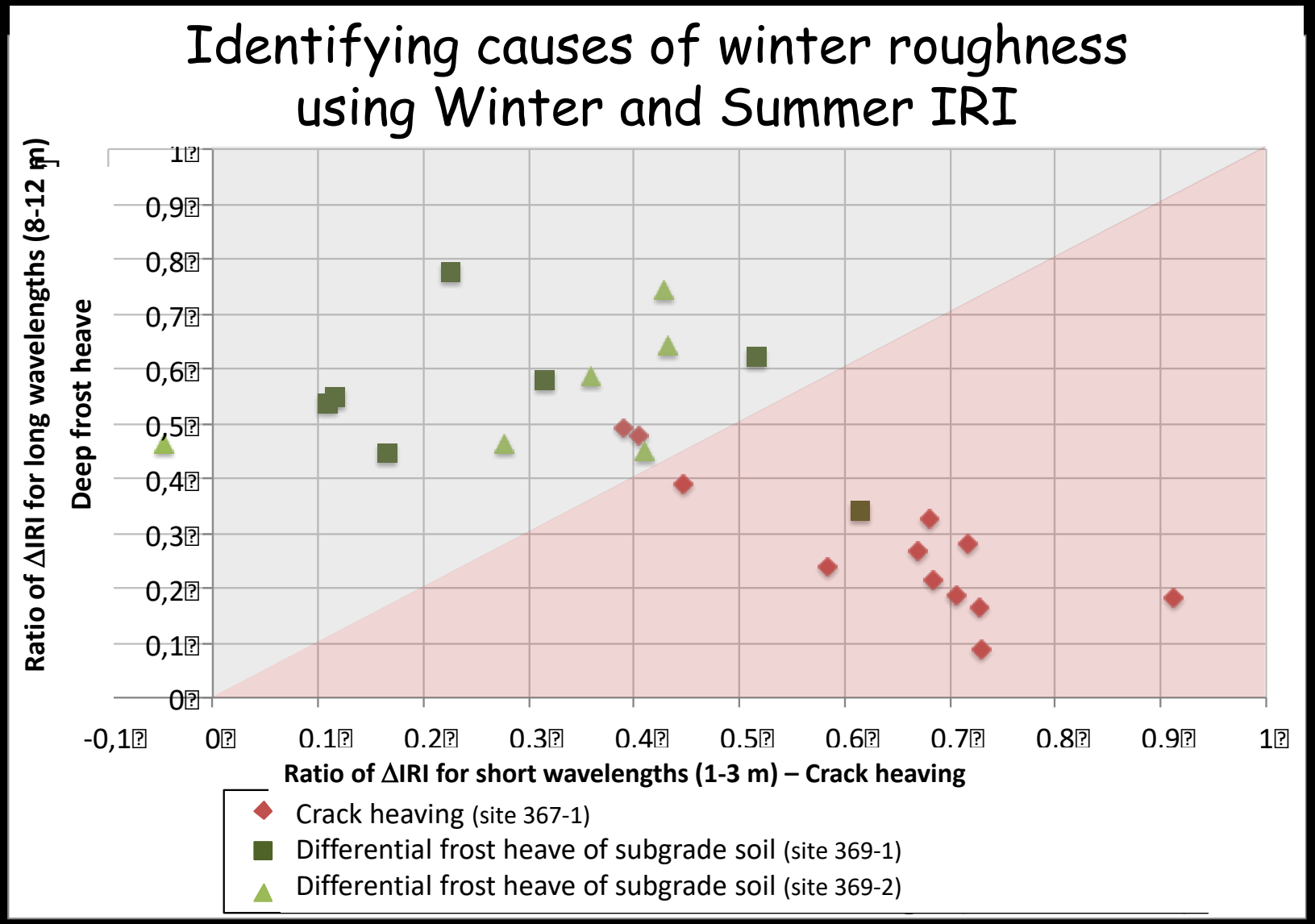


In seasonal frost contexts

IRI is higher in Winter

$$\frac{\Delta\ IRI_{\ (Winter - Summer)}\ \textbf{filtered}}{\Delta\ IRI_{\ (Winter - Summer)}\ \text{unfiltered}}$$

Summary – Longitudinal profiles



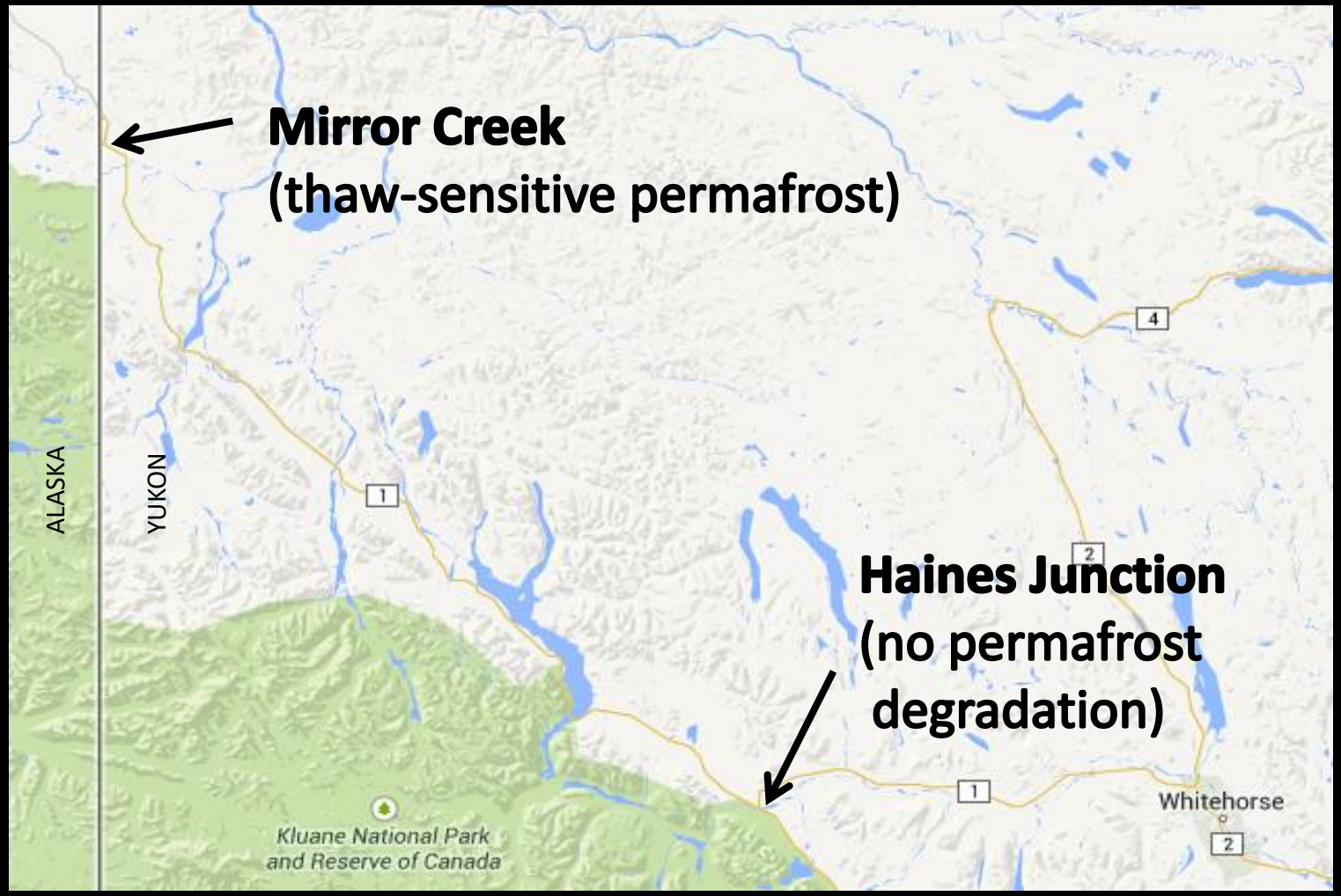
PERMAFROST

Methodology

Data acquisition

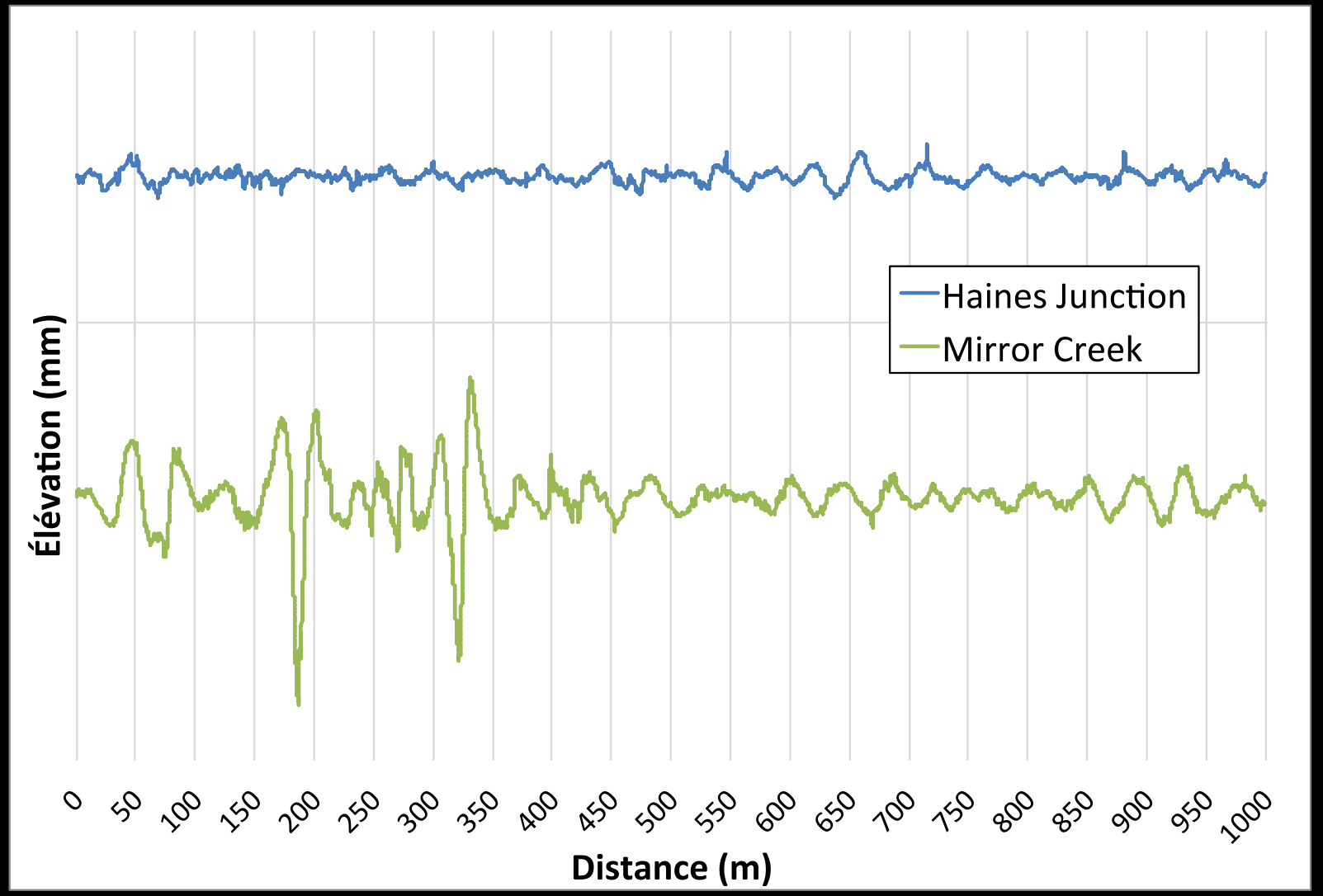
Surpro

low speed walking profiler

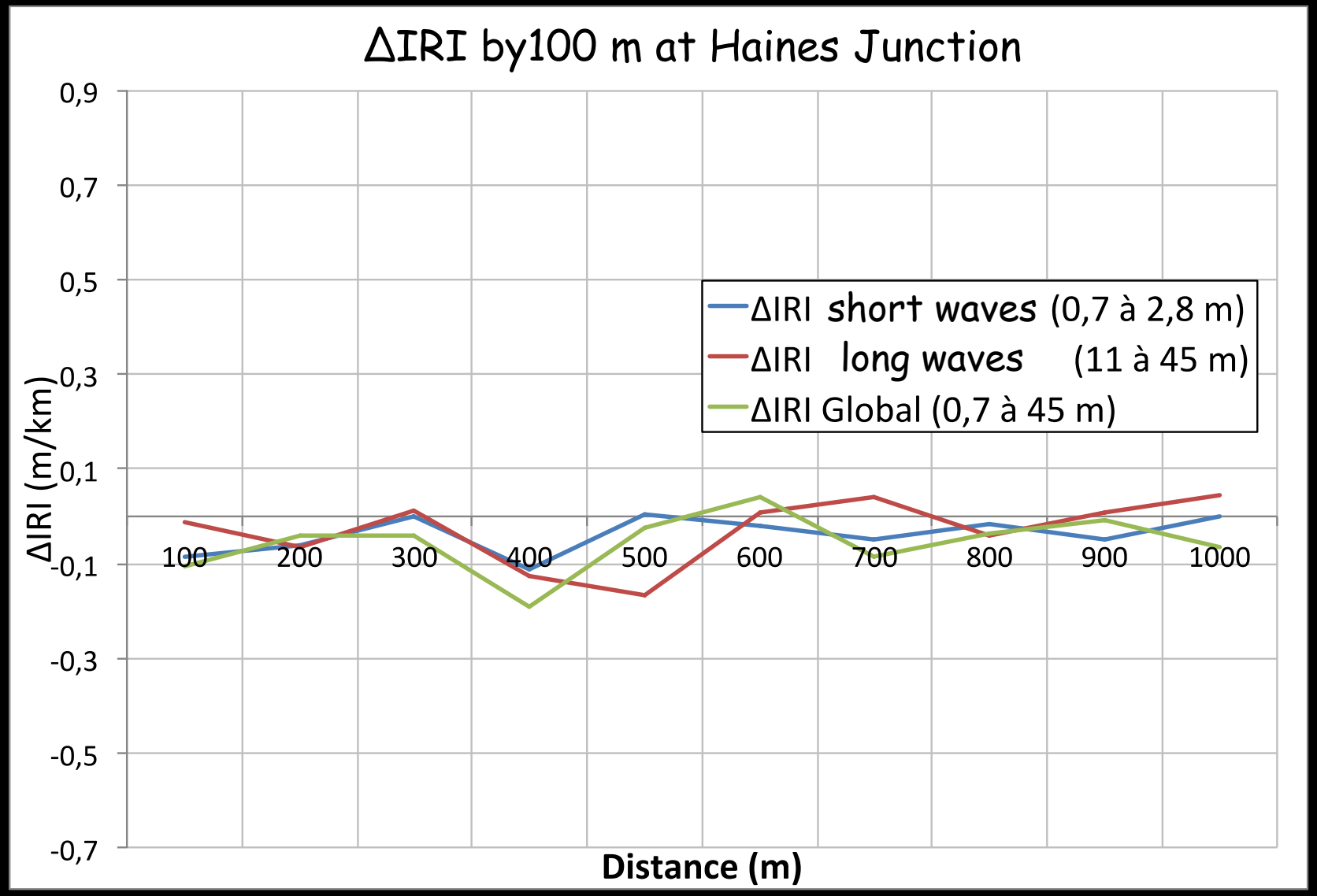


Results

Unfiltered longitudinal profiles



Haines Junction – no permafrost degradation issues

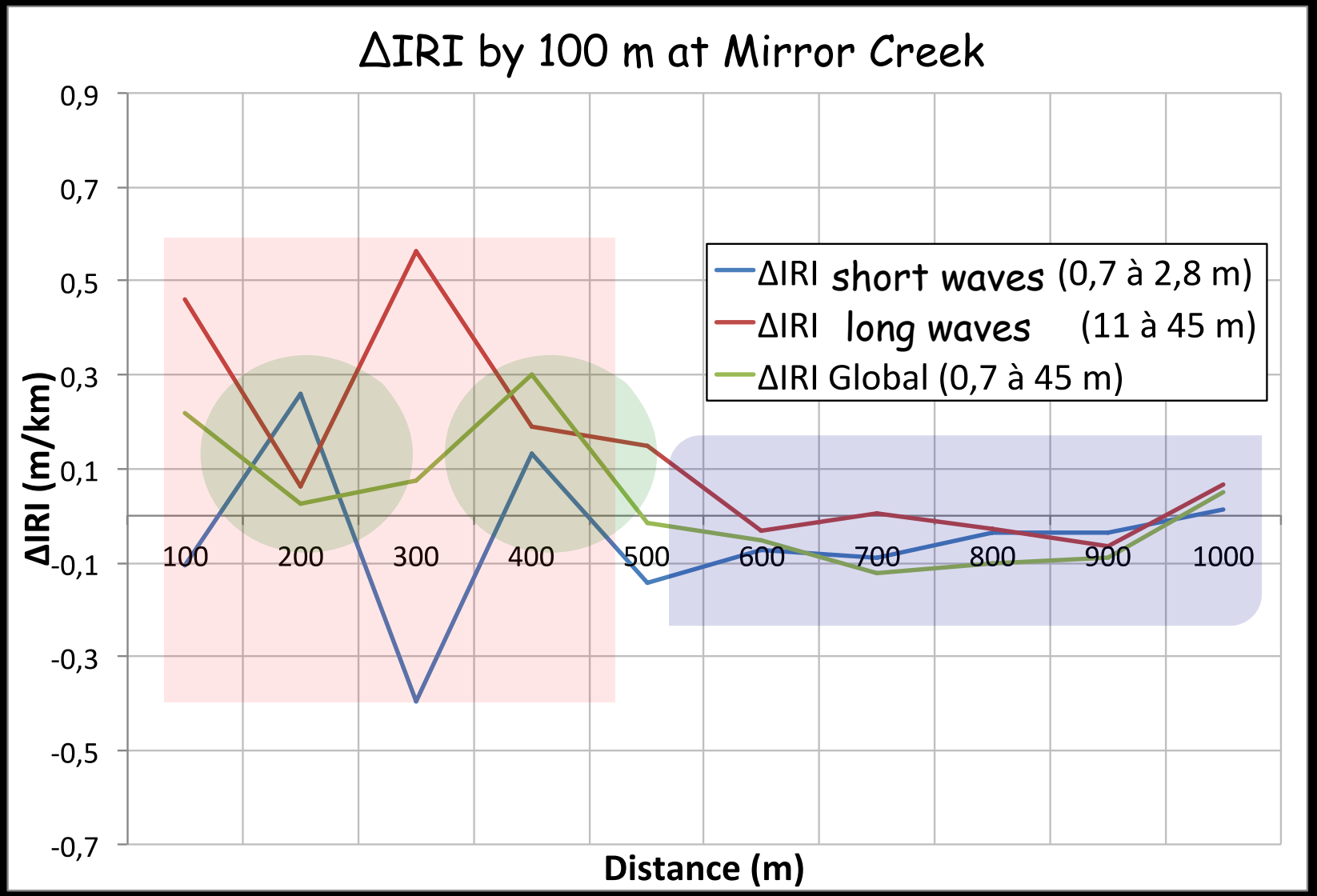


In permafrost contexts IRI is higher in early Fall due to thawing and uneven settlements

$$\frac{\Delta\ IRI_{(Fall - Spring)}\ \textbf{filtered}}{\Delta\ IRI_{(Fall - Spring)}\ \textbf{unfiltered}}$$

Fall = September (maximum thaw)
Spring = April (maximum freeze)

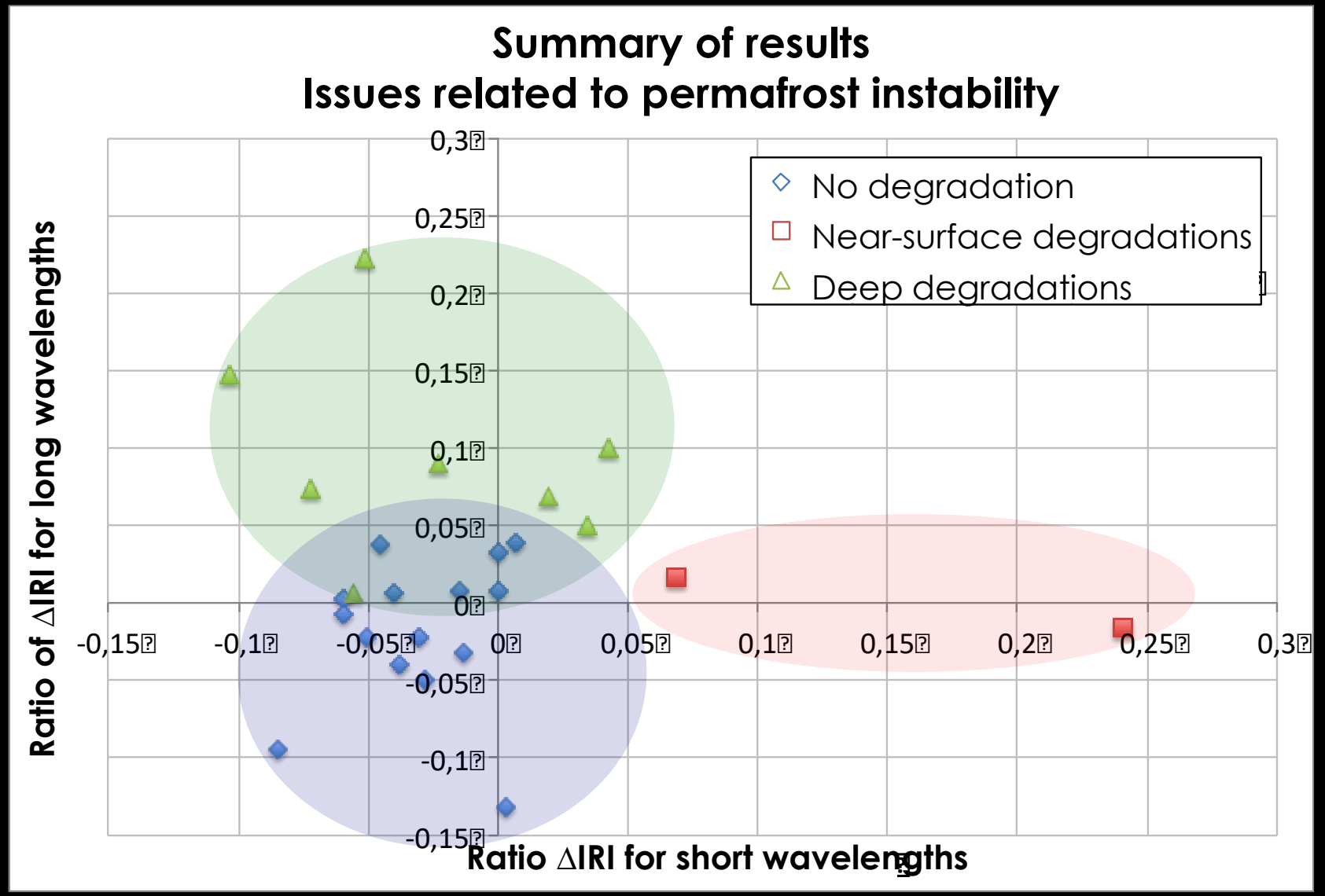
Mirror Creek – thaw-sensitive permafrost



$$\frac{\Delta\ IRI_{(Fall - Spring)}\ \textbf{filtered}}{\Delta\ IRI_{(Fall - Spring)}\ \text{unfiltered}}$$

Fall = September (maximum thaw)
Spring = April (maximum freeze)

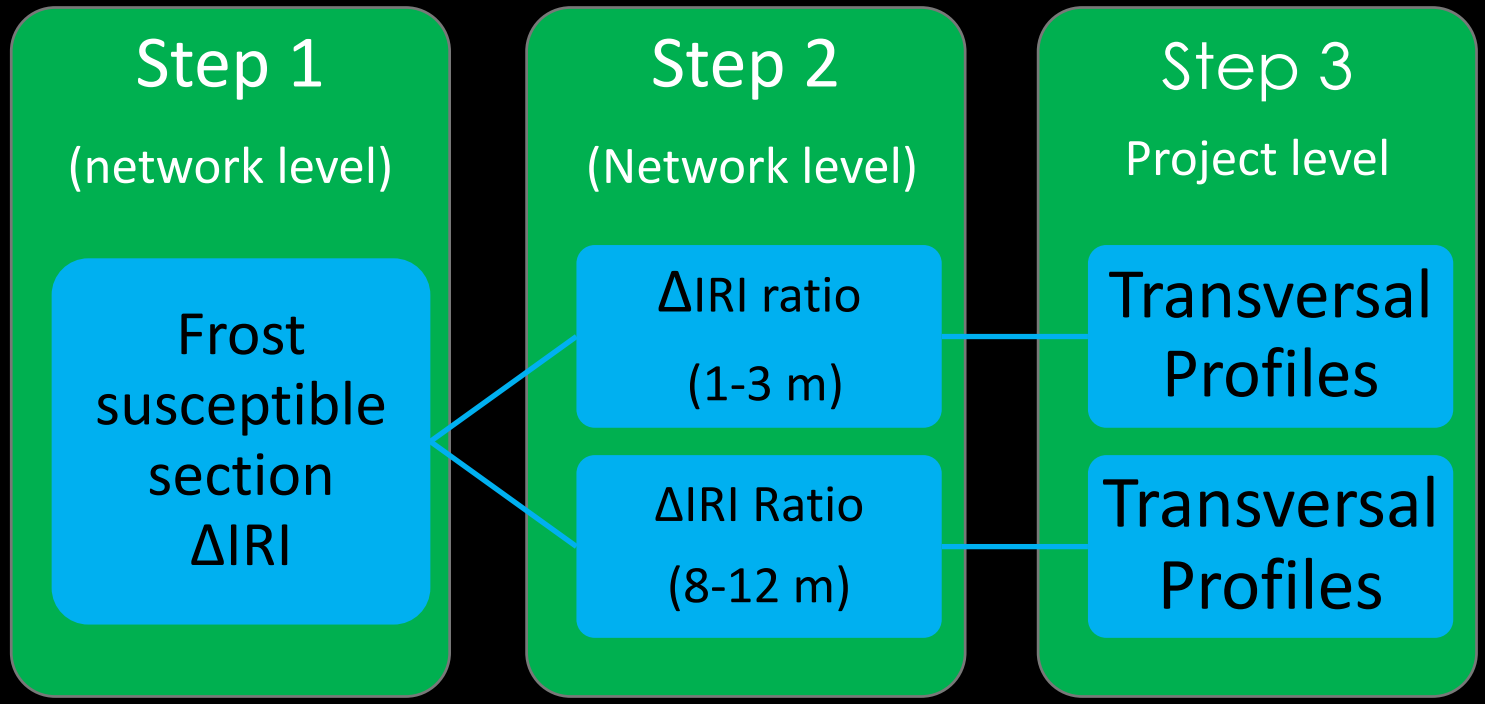
Summary – Permafrost context



Conclusion

- Tool developed to help identifying causes of winter roughness using surface profile analysis in seasonal frost context

- Can be used to identify road sections affected by frost action (ΔIRI) and cause of deterioration (ΔIRI ratio)



- Based on limited data and with a few adjustments, the technique appear to be applicable for the early detection of road sections affected by permafrost degradation

Benefits

- A methodology and preliminary criteria for:
  - Identification of causes of winter roughness related to frost action in seasonal frost contexts
  - Early detection of permafrost degradation under transportation embankments in permafrost environments

Englobe

Tarquluk
Permafrost engineering research program
Programme de recherche en ingénierie du pergélisol

i3c Phase 2
Chaire de recherche industrielle du CRSNG sur l'interaction charges lourdes-climat-chaussées

Université Laval

THANK YOU

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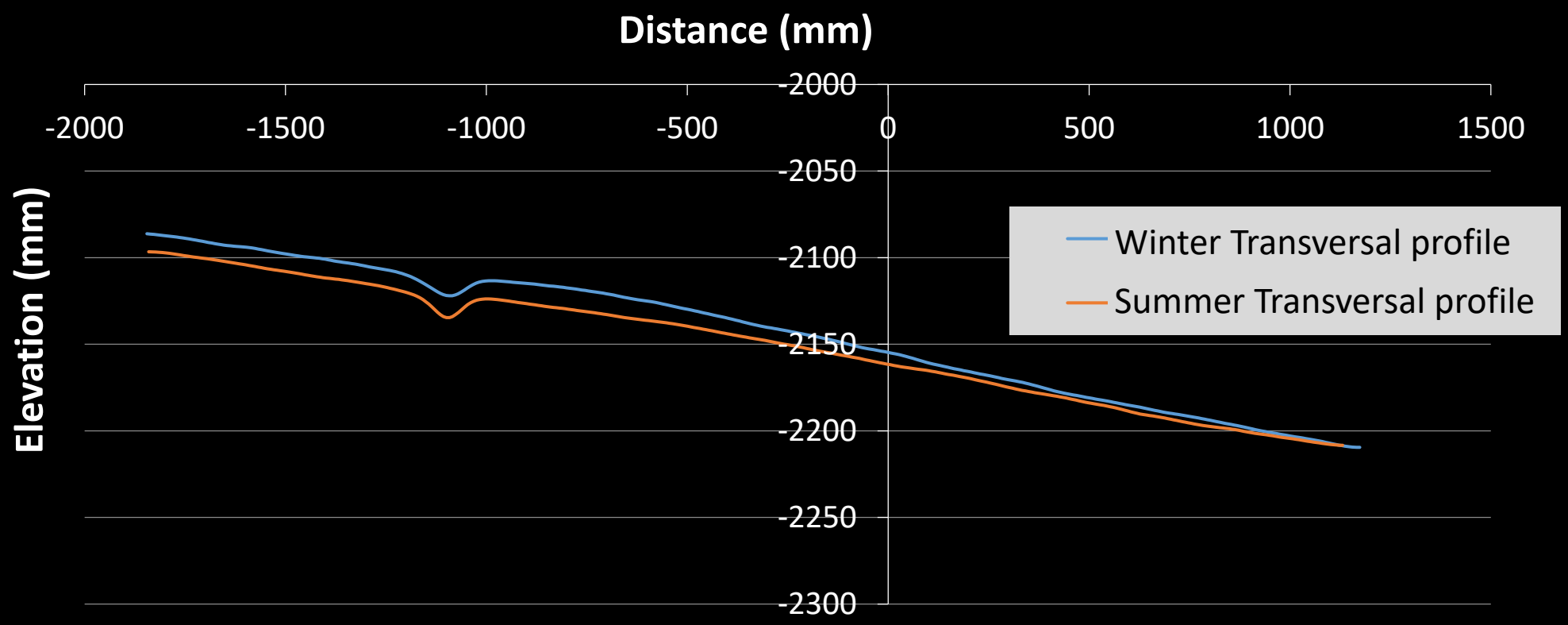
Transversal profiles



Transversal Frost Heaving Index (TFHI)
based on the Root Mean Square Error (RMSE)